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LUNAR PHYSICAL PARAMETERS STUDY

PARTIAL REPORT NO. 15

BREADBOARD TESTS OF THE SURFACE AND SUBSURFACE DENSITY MEASURING DEVICES

WORK PERFORMED UNDER J.P.L. CONTRACT NO. N-33552

SEPTEMBER 20, 1961

TEXACO
INC.

RESEARCH AND TECHNICAL DEPARTMENT

EXPLORATION AND PRODUCTION RESEARCH DIVISION

BELLAIRE, TEXAS

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BREADBOARD TESTS OF THE SURFACE AND SUBSURFACE DENSITY MEASURING DEVICES

Introduction

The results of the feasibility study concerning the measurement of density on the surface of the moon as presented in Partial Report No. 1[1], were, briefly, as follows:

1. The density of materials in the range of 1.5 gm/cm^3 to 4.5 gm/cm^3 can be determined by a modified gamma radiation transmission method.
2. A density device can be made which will partially compensate for surface irregularities over a prescribed range of densities.

Using the same theory as outlined in Partial Report No. 1, a subsurface density device was designed and built which has the same range of measurement as the surface device.

Object

To obtain performance data as described in OUTLINE OF BREADBOARD TESTS EXPERIMENTS[2].

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[1] Partial Report No. 1, Measurement of Lunar Surface Density, A Feasibility Study, Aug. 31, 1960, 1:794.5

[2] Outline of Breadboard Tests Experiments, May 10, 1961, 1:794.30

Description of Apparatus

The surface density instrument was built as shown in Fig. 1. This instrument has a 7 in. spacing between the center of the source and the nearest portion of the counter. The spacing between the extremities of the lead source shield and the lead detector shield is 5 in. This device is built to house a geophone which is used in the surface acoustic velocity experiment. The counter selected for breadboard tests is an Anton No. 356; this was the only counter that was available off the shelf which was suitable in size and would take the extreme temperature conditions to which a flight model might be subjected. The counter is a 3 in. by 5/8 in. tube with a 10 mil stainless steel wall. A 1 mil layer of tungsten has been plated on the inner wall and the counter is filled with halogen gas. Pigtail leads were specified to facilitate ease of making connections to anode and cathode.

For the breadboard tests a 31 millicurie Cesium-137 source was used.

Subsurface Density Instrument

The subsurface density instrument was built as shown in Fig. 2. The minimum spacing between the counter and source is 7 in. The counter tube is an Anton No. 356, the same tube that is used in the surface instrument. Since the maximum dimension of the sonde without decentralizer spring is 7/8 in., only 1/8 in. of shielding material is available around the counter. To get the best shielding possible a high Z and high density material with high strength must be used. The material selected is an alloy of tungsten, trade named Mallory 1000. A window opening 1/4 in. wide and 2-1/4 in. long was made along the axis of the counter, this opening is on the decentralized side of the sonde and is in line with the source collimator opening. The source collimator opening is 1/8 in. in diameter bored at a 45° angle in a 7/8 in. diameter by 1-5/8 in. long Mallory 1000 cylinder. The source used for this experiment consisted of 100 millicuries of Iodine-131 placed in a container 1/8 in. in diameter and 7/8 in. long.

Standards

The density standards used by the laboratory consisted of 1 ft. cubes of Carthage marble ($\rho = 2.65$ gm/cm^3), Austin chalk ($\rho = 1.95$ gm/cm^3), "Featherstone" lava ($\rho = .75$ gm/cm^3), and a block of Balsa wood ($\rho = .14$ gm/cm^3), 12 in. x 12 in. x 18 in. Simulated boreholes were made by drilling 1-1/4 in. and 1-3/4 in. holes through the stones and the Balsa wood. To make a standard large enough for surface measurements two blocks of identical stone were used side by side.

Surface protuberances were simulated by using 1 in. x 4 in. x 4 in. blocks of Carthage marble, Austin chalk, and lava.

Experimental Results

Surface Density Instrument

A complete set of data was taken on all standards and plotted as response (counts/sec) vs. density (gm/cm^3) as shown in Fig. 3. This figure shows that (1) the response has a maximum when the density is about 0.5 gm/cm^3, (2) with densities approaching zero the response approaches the natural background plus any gammas that are not absorbed by the source and detector shields, and (3) with very dense materials the response would again approach the background as mentioned in (2). To remove any ambiguity of interpretation, a reading should first be made with the detector end of the instrument raised approximately 1/2 in. from the rest position on the material and then a second reading should be made in the rest position. If the counting rate observed with the density tool resting on the surface is less than that observed with the instrument slightly elevated, the density of the material being measured is greater than 0.5 gm/cm^3. If the density is less than 0.25 gm/cm^3, the response will be greater with the density tool resting on the surface than with the tool slightly elevated. This can be explained by assuming that the effective density of the material within the measured volume has increased when the instrument is moved from a slightly elevated to a rest position on the surface. With these two readings and a calibration curve the density of the unknown material can be determined.

The shape of the source collimator and detector shield are designed to compensate for surface irregularities. Fig. 4 is a plot of response vs. height of surface protuberances for the Carthage marble, Austin chalk and lava. This data was taken with 1 in. x 4 in. x 4 in. squares of rock which have a density identical to the density of the main body placed under the source end of the device for one set of measurements and under the detector end for the second set. The percentage error is shown on the right hand margin of Fig. 4, Carthage marble and Austin chalk with densities of 2.65 and 1.95 gm/cm^3 show that a maximum error of 16% exists. However, data taken using lava with a density of .75 gm/cm^3 shows that little or no compensating effect exists.

In Partial Report No. 1 it is suggested that a picture of the device on the lunar surface will aid in the interpretation of the data. From this picture it would be possible to model the surface using different density materials. When a similar type instrument placed in position on the model indicates the same response as exhibited by the instrument on the lunar surface the density of the material measured can be determined.

Subsurface Density Instrument

A complete set of data was taken in the 1-1/4 in. and the 1-3/4 in. boreholes of all samples. This data was plotted and is shown in Fig. 5 as response (counts/sec) vs. density

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(gm/cm^3) for each borehole size. A 100 millicurie Iodine-131 source was used with an Anton No. 356 counter. This plot shows that density is a double valued function of response similar to that found with the surface instrument with a peak response at about 0.5 gm/cm^3. Interpretation of data can be made by first taking a reading when the counter is in the borehole and the source is approximately 1 in. above the surface, then dropping the sonde 2 in. and taking a second reading. If the density of the surface layer is greater than 0.5 gm/cm^3 the response will decrease - if the density is less than 0.25 gm/cm^3 the response will increase. This experiment, using the subsurface sonde, is much more reliable than the experiment using the surface instrument because protuberances on the surface might cause considerable error and the instrument could be partially covered with an unconsolidated material.

An error exists due to hole size variations, but, with a suitable calibration curve, and with information as to hole size variations from the caliper attached to the subsurface sonde, a positive density interpretation can be made.

Discussion

The surface and subsurface density measuring instruments will make density measurements on materials ranging from 0.1 gm/cm^3 to 4.5 gm/cm^3. The surface instrument will partially compensate for surface irregularities if the density of the material being measured is greater than 2 and the protuberances are less than 4 in. The maximum error that existed in making these measurements was 16% of the true density. With information taken from a picture of the instrument in the operating position on the lunar surface, an experiment can be conducted in the laboratory to reduce this percentage error. The subsurface instrument is sensitive to hole size variations, however, with a calibration curve showing response in different diameter boreholes and knowing the borehole diameter, it is possible to accurately interpret the data. Calibration curves for both the surface and subsurface instruments show density as a double valued function of response. A method is given in this report which will remove any ambiguity of interpretation.

Conclusions

1. The surface and subsurface instruments will make density measurements on materials ranging from 0.1 gm/cm^3 to 4.5 gm/cm^3.
2. A correction can be made for errors due to surface irregularities and for hole size variations.
3. A method is given to acquire the necessary data for determining the correct density from a calibration curve which shows density as a double valued function of response.

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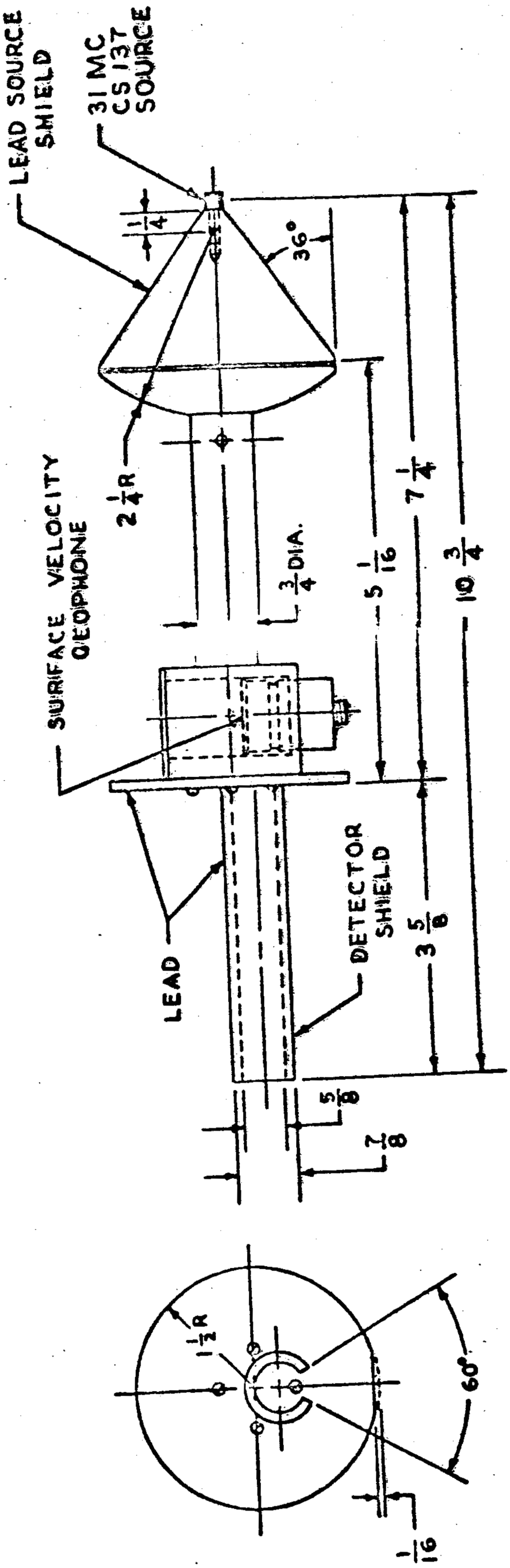

FIGURE 1
SURFACE DENSITY INSTRUMENT

1:794.43-8
1:794-94

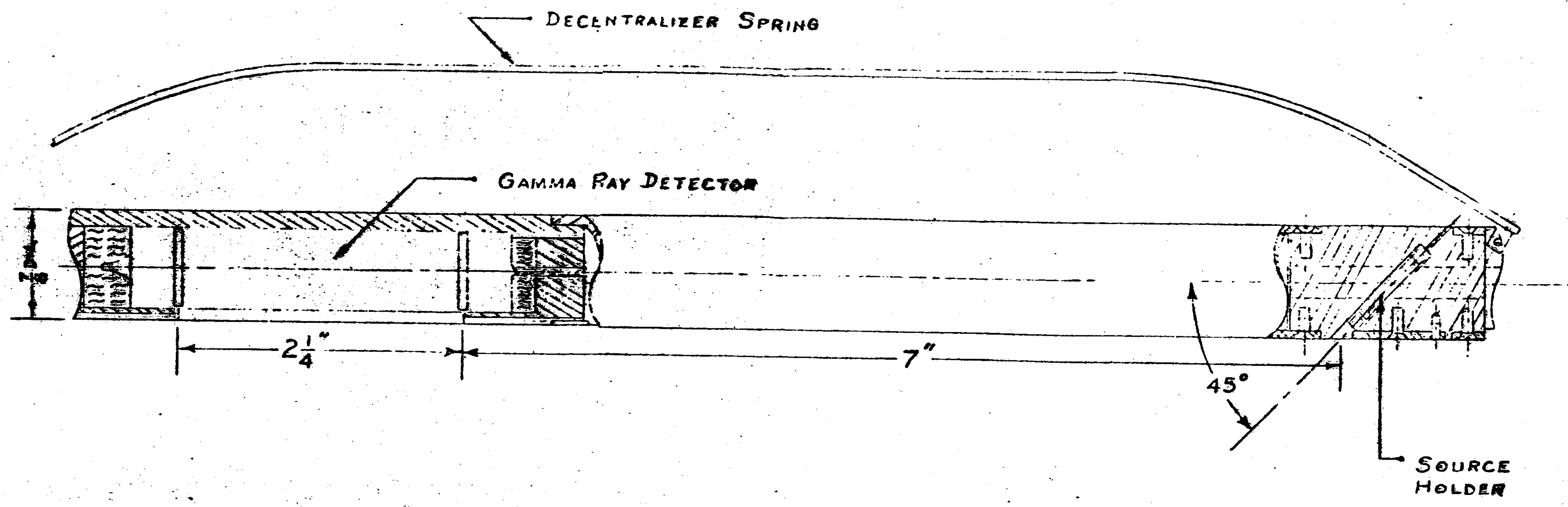

FIGURE 2
SUBSURFACE DENSITY INSTRUMENT

1:794.43-9
1:794-95

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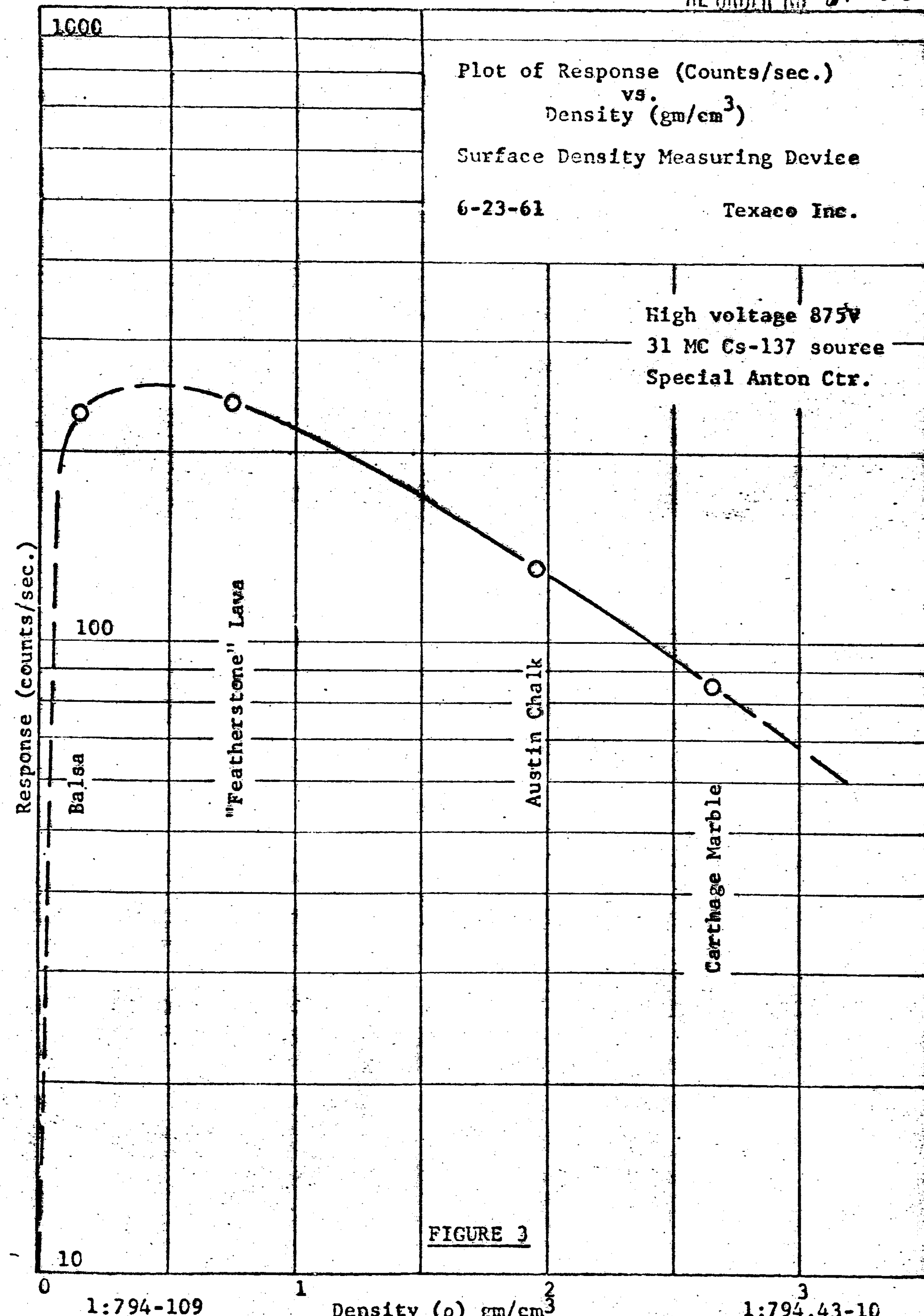

1:794-109

1:794.43-10

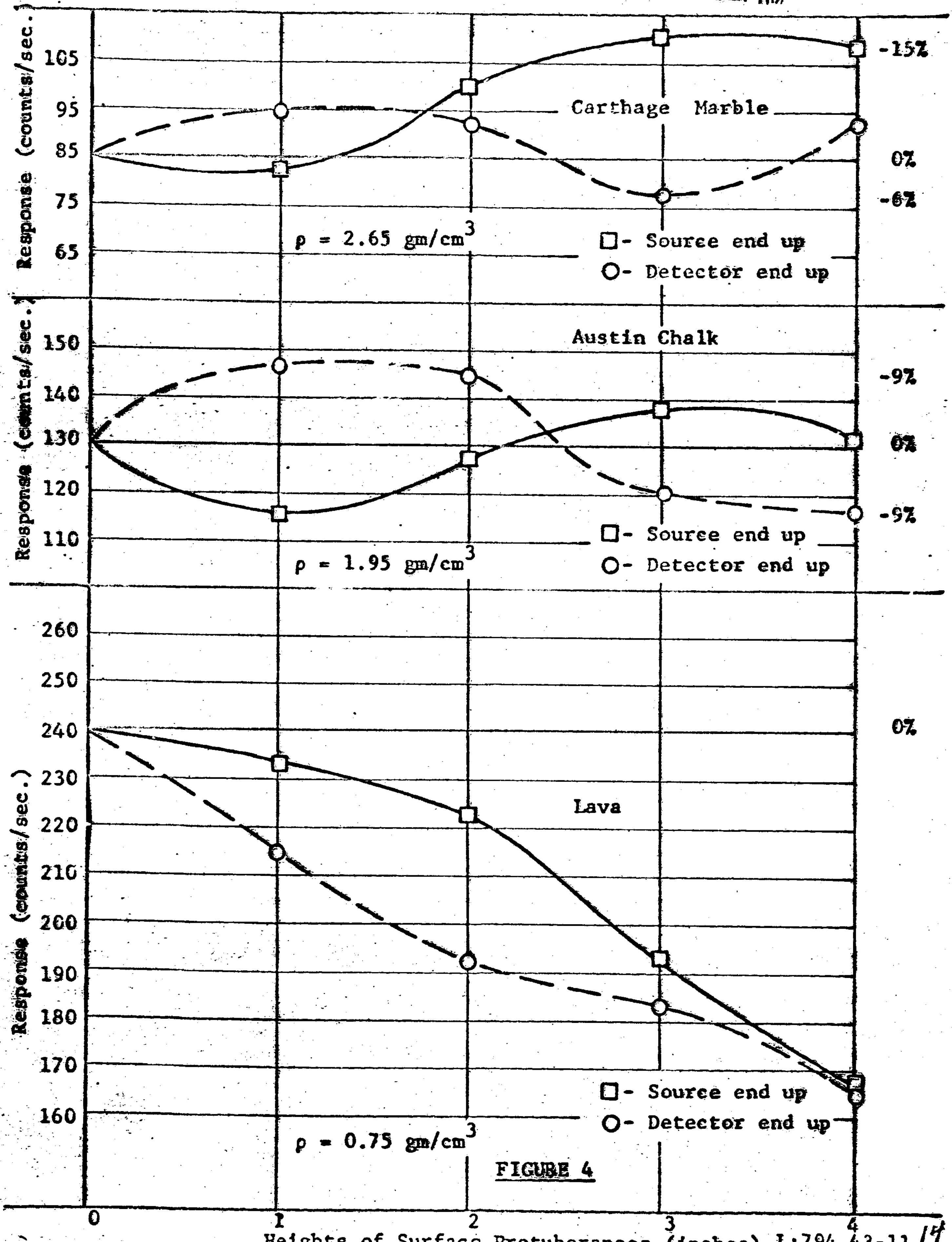

FIGURE 4

L:794.43-11
1:794-110

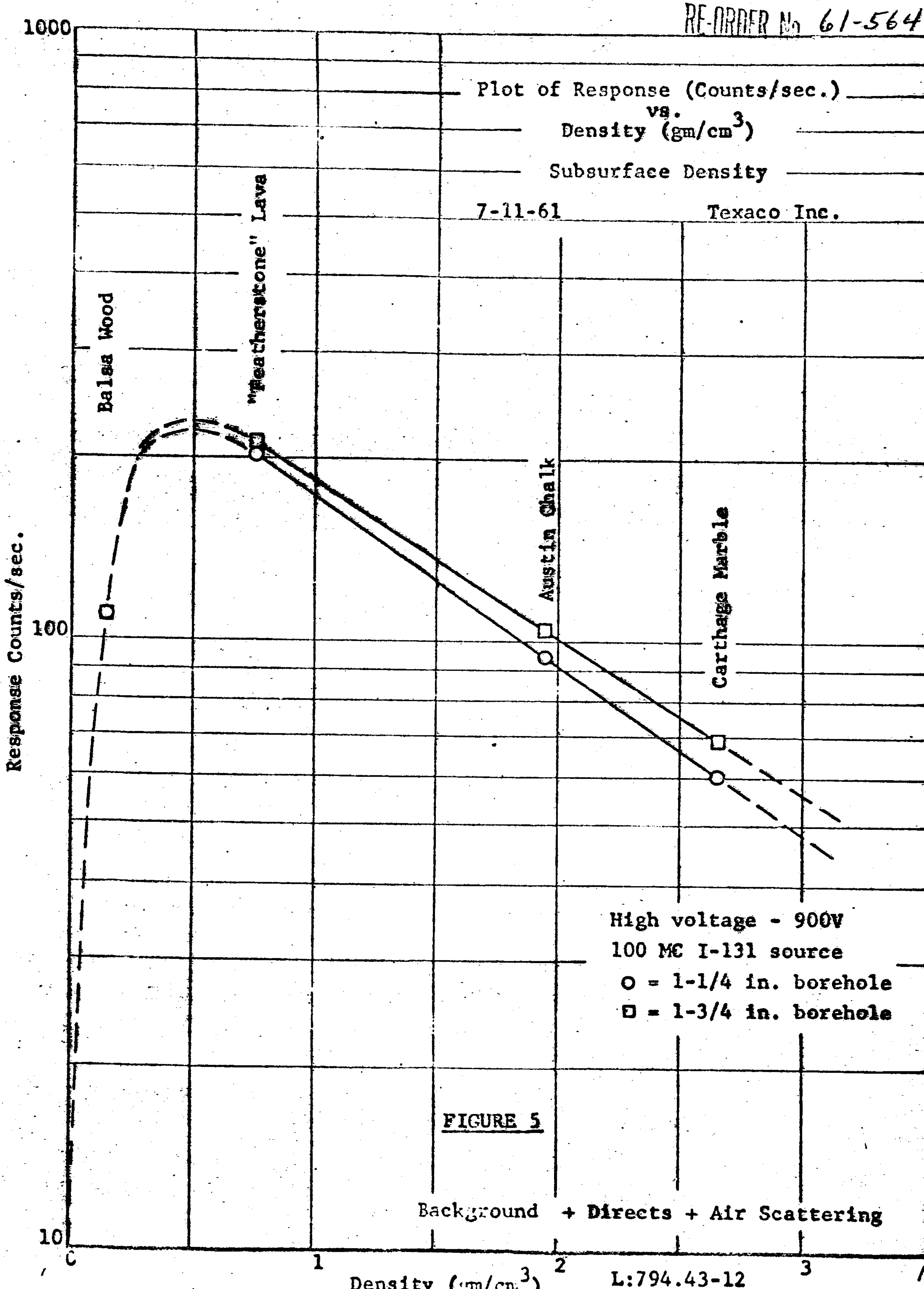

FIGURE 5

L:794.43-12
1:794-111